

Attachment 1

**Alaska Department of Environmental Conservation
Decision Document for Site-Specific Criteria (SSC) for Bass Creek,
Middle Creek and Lone Creek, Tributaries of the Chuit River and Lower
Chuit River to Tidewater Terminus**

Public Notice Draft

July 25, 2014

Deliberative DRAFT

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I. Proposed Department Decision

A water quality standard defines the goals for a water body by designating uses, setting criteria to measure attainment of those uses, and establishing policies to protect water quality from pollutants. Under CFR 131.11(b)(1)(ii) states are to establish numeric values based on guidance modified to reflect site-specific conditions. In accordance with 18 AAC 70.235, the Alaska Department of Environmental Conservation (DEC) proposes to establish site-specific criteria (SSC) for aluminum, copper, zinc, and manganese for Bass Creek, Middle Creek, Lone Creek, and the lower Chuit River, Alaska. The three creeks are tributaries of the Chuit River, which is located in Southcentral Alaska and within the project area of the Chuitna Coal Mine project proposal by PacRim Coal.

The project does not currently propose or include any processing or chemical treatment of the coal other than crushing and dust control systems. All water managed by the project is a combination of storm water (rain fall and snow melt) and groundwater. The intent of seeking SSC, conducted under guidelines established under the Clean Water Act (CWA) and Alaska state statutes, is to adjust water quality standards that will be used to establish potential effluent limits that are protective of aquatic life and human health, but also reflect the natural hydrogeology present in the Chuit watershed.

DEC finds that the evidence reasonably demonstrates that:

1. The proposed SSC for aluminum, copper, zinc, and manganese will fully protect the designated uses in 18 AAC 70.020(b) [see 18 AAC 70.235(c)];
2. The water quality criteria for aluminum, copper, zinc, and manganese in 18 AAC 70.020(b) are more stringent than necessary to ensure full protection of the corresponding use class; [see 18 AAC 70.235 (c)(1)]; and
3. The natural characteristics of the receiving environment would reduce the biological availability or the toxicity of aluminum, copper, and zinc or otherwise alter these

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substances, and SSC are required to alleviate unnecessarily restrictive general criteria [see 18 AAC 70.235(d)(2)].

DEC's findings are based on the following factors:

1. Aluminum, copper, and zinc – Aquatic Life – Fresh Water (see Table 1)
 - a) Toxicity tests in laboratory water and creek water from the site were compared using EPA's Water Effects Ratio (WER) Procedures (USEPA, 1994b and 2001). The WER testing was used to evaluate the degree of toxicity from exposure to copper, and zinc concentrations on the water flea (*Daphnia magna*) and fathead minnow (*Pimephales promelas*). Only fathead minnows were tested for aluminum toxicity. The WER tests were parameter specific and completed according to EPA guidance.
 - b) Multi-metal confirmation WER tests were to address the potential for additive effects or potential interactions among these metals. The concentrations of metals used in the mixed metals tests were based on the results of the singular effects from the individual aluminum, copper and zinc WER tests (Tetra Tech, 2011).
 - c) Review of the results from the individual and confirmatory tests concluded that the individual WER values were the most appropriate values to derive the proposed SSC.

Table 1: Summary of Proposed SSC and Alaska Water Quality Criteria for Aluminum, Copper, and Zinc (Aquatic Life – Fresh Water)

Parameter ¹	Proposed SSC (µg/L)		Alaska Water Quality Criteria (µg/L)	
	Acute	Chronic	Acute	Chronic
Aluminum ²	750	650	750	87
Copper	22	17	3.64	2.74
Zinc	43	43	36.5	36.5

1. Copper and zinc criteria for aquatic life are expressed as dissolved metal concentrations calculated based on a hardness of 25 mg/l as CaCO₃

2. Aluminum value is in total rather than dissolved concentration per Alaska water quality criteria.

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2. Manganese – Human Health Criteria for NonCarcinogens (see Table 2)

- a) Manganese values were recalculated using EPA’s Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health. EPA-822-B-00-004, published in 2000.
- b) Local fish consumption rate estimates derived from Alaska Department of Fish and Game (ADF&G) harvest data and a reference dosages based on drinking water advisories for manganese were used to derive the SSC.

Table 2: Summary of Proposed SSC for Manganese

(A) Water supply	Proposed SSC $\mu\text{g/L}$	Alaska Water Quality Criteria $\mu\text{g/L}$
(i) Drinking, culinary, and food processing;	Human Health for Consumption of Water + Aquatic Organisms: 300	Human Health for Consumption of Water + Aquatic Organisms: 50
(C) Growth and propagation of fish, shellfish, other aquatic life and wildlife	Human Health for Consumption of Aquatic Organisms Only: 300	Human Health for Consumption of Aquatic Organisms Only: 100

2. Review of written and oral comments received during the public comment period

TO BE INCLUDED AFTER PUBLIC COMMENT

II. Background Information on the Chuit River Watershed and the Proposed Chuitna Coal Project

A. Location

The Chuit River watershed is located in southcentral Alaska on the west side of the Cook Inlet approximately 40 miles west of Anchorage. The watershed occurs within the Cook Inlet-Susitna Lowlands physiographic sub province (Riverside Technology Inc., 2007), a broad lowland that generally lies below an elevation of 1,000 feet bounded by the Alaska Range to the west and the Talkeetna Mountains to the east. The region is mantled by metal-rich deposits of glacial origin overlying tertiary-aged sedimentary rocks. The area has relatively gentle but irregular topography with discontinuous hills and numerous depressions typical of highly glaciated terrains (PacRim Coal, 2009).

The Chuit River watershed is undeveloped and divided into five different drainages: lower Chuit River, upper Chuit River, Bass Creek, Middle Creek, and Lone Creek. The proposed mine project area is primarily within the Bass Creek, Middle Creek, and Lone Creek watersheds (See Figure 2). PacRim refers to Bass Creek, Middle Creek, and Lone Creek as 2002, 2003, and 2004 Creeks respectively in their reports and in Figure 2. The Chuit River watershed is noted as #20 in Figure 1 (Chuitna Project Areas and SSC Watersheds).

B. Proposed Project Description

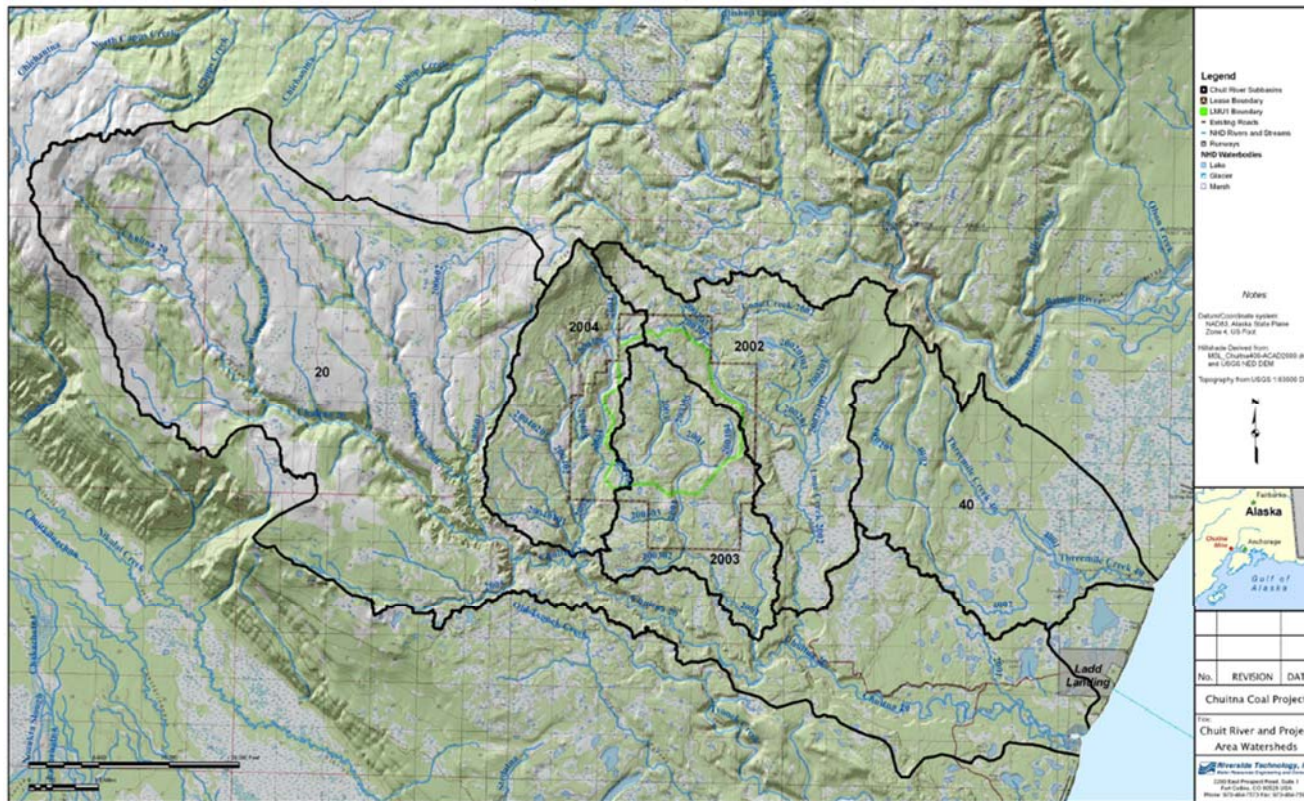
The Chuitna Coal Project is a surface coal mine and export development project for ultra-low sulfur, sub bituminous coal located in the Beluga Coal Field (PacRim Coal, 2009). The project proposal consists of a surface coal mine and associated support facilities, mine access road, coal transport conveyor, personnel housing, air strip facility, logistic center, and coal export terminal (Map 1). The project predicts a minimum 25-year mine life with a production rate of up to 12 million tons a year (PacRim Coal, 2009). The proposed mine project area is located within the watersheds of Bass, Middle, and Lone Creeks (See Figure 2). PacRim is requesting relief from the designated use of agriculture (irrigation) due to numerous physically, biologically, and chemically limiting factors that preclude this use from

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occurring on a year-round basis and is requesting site-specific criteria for aluminum, copper, manganese, and zinc.

The water chemistry data for the proposed SSC parameters has been collected in the Chuit River watershed at different occasions the past 30 years and most extensively over the past five years. Several metals are noted to naturally exceed state water quality criteria (Riverside Technologies Inc., 2007, 2009). Periods of especially elevated metal concentrations were noted to coincide with elevated concentrations of total suspended solids and increased stream discharge periods. Groundwater samples taken in the immediate vicinity of the proposed project area were also noted to have elevated concentrations of metals (Riverside, 2008).

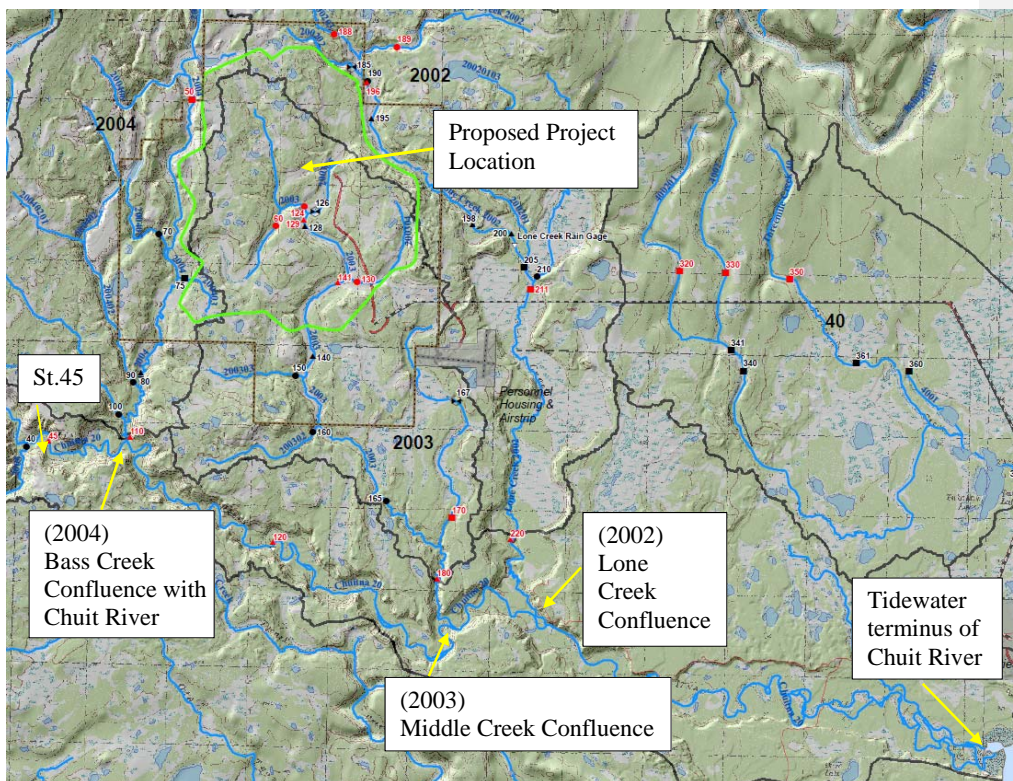
Figure 1: Chuitna Project Area and SSC Watersheds (Riverside, 2009)



C. Area of Site Specific Criteria Application

The waterbodies where the SSC apply are Bass Creek (2002), Middle Creek (2003), Lone
Creek (2004), and the main stem of the Chuit River (20) (aluminum and manganese) below
Lone Creek and concluding at the tidewater terminus at Cook Inlet are shown in Figure 2.

Figure 2: Location of water bodies affected by SSC (Riverside, 2009)



III. Proposed Site-Specific Criteria

The Alaska water quality criteria for the four metals proposed for SSC are listed in Table 3. The process for modifying the water quality criteria for aluminum, copper, and zinc is described in Section ii and the conclusion is in Section iii. The process for modifying the water quality criteria for manganese is described in Section III B.

Table 3. Alaska Water Quality Criteria for Metals of Concern in the Chuit River Watershed.

Pollutant	Aquatic Life Criteria		Human Health Criteria for the Consumption of:	
	Acute (µg/L)	Chronic (µg/L)	Water + Aquatic Organisms (µg/L)	Aquatic Organisms Only (µg/L)
Aluminum ¹	750	87	--	--
Copper ²	3.64	2.74	1,300	--
Manganese ¹	--	--	50	100
Zinc ²	36.5	36.5	9,100	69,000

1. Aluminum and manganese criteria are expressed as total metal concentrations

2. Copper and zinc criteria for aquatic life are expressed as dissolved metal concentrations calculated based on a hardness of 25 mg/l as CaCO₃.

A. Aluminum, copper, and zinc

i. Regulatory Background

The aquatic life criteria for aluminum, copper, and zinc protect the designated use for growth and propagation of fish, shellfish, and other aquatic life and wildlife, are based on EPA's nationally recommended water quality criteria. When the national water quality criteria were calculated, fish, invertebrates, and plants were exposed to known concentrations of metals in laboratory water to determine at what concentration toxic effects were observed. The current Alaska aquatic life criteria are based on those tests.

A number of factors, such as hardness, organic carbon, and total dissolved solids are recognized as having the ability to decrease the degree of toxicity from dissolved metals. Copper and zinc criteria vary depending on water hardness, because water hardness affects the level of metal toxicity. In developing criteria, EPA acknowledged that criteria were

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designed to be generic and would be expected to be under- or over-protective of the aquatic community in some systems (Stephan, et al., 1985).

To account for these site-specific differences, EPA developed guidance for modifying, updating, and correcting water quality criteria. Two methods are approved of by EPA for modifying water quality criteria: 1) the recalculation procedure, and 2) the WER procedure (USEPA, 1994; USEPA, 2001). Either method is appropriate and can be used to modify the acute and chronic aquatic life criteria for aluminum, copper, and zinc. PacRim Coal selected the WER procedure to test the degree of toxicity to aquatic life from sample site water(s) and the feasibility of changing the acute and chronic water quality criteria for aluminum, copper, and zinc for selected reaches of the Chuit River watershed.

ii. Evidence Supporting Site Specific Criteria Proposal

According to 18 AAC 70.235(e), the applicant (i.e. PacRim Coal) shall provide information that DEC determines is necessary to modify an existing criterion. PacRim Coal submitted individual WER test results as evidence for proposed SSC for aluminum, copper, and zinc. PacRim Coal also submitted confirmatory WER multi-metal test results as a supporting documentation for this process. A review of both the individual and the confirmation testing is included in this section. Lead was originally considered for SSC but was rescinded by PacRim following completion of the individual and mixed metals confirmatory test process. As a result, lead is not referenced in this report.

Method for Calculating the SSC

The WER procedure is a standard EPA protocol which calculates the site-specific bioavailability of certain metals in the representative site water relative to that of the bioavailability in standard laboratory water. The ratio of toxicity between site water and the laboratory water is the WER. The ratio is then multiplied by the statewide acute and chronic water quality criteria independently to create a SSC that is adjusted for the site specific chemistry of the site water. The proposed WER value represents the geometric mean of several rounds of testing. Final WER values were calculated for aluminum based on

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Pimephales promelas (fathead minnow) toxicity data and for copper and zinc based on *Daphnia magna* (water flea) and *pimephales promelas* toxicity data, consistent with EPA guidance.

The equation used to derive the WER-based SSC is:

$$\text{Site Specific Criteria (SSC)} = \text{Water Effects Ratio (WER)} \times \text{Ambient Water Quality Criteria (AWQC)}$$

Individual WER Analysis

A study plan for developing SSC was initially developed by PacRim contractor Tetra Tech in July 10, 2009 (PacRim Coal, 2009). Tetra Tech's study plan used EPA's WER testing procedures and reflected the guidance given in the *Interim Guidance on the Use of Water Effect Ratios for Metals* (USEPA, 1994b) and *Streamlined Water-Effect Ratio Procedure for Copper* (USEPA, 2001). The study plan included a quality assurance project plan for conducting a WER (PacRim Coal, 2009), which was reviewed by DEC. The applicant selected the WER procedure because the characteristics of Chuit River are significantly different from the laboratory water used to derive the national and state aquatic life criteria. It was determined prior to commencing WER testing that completing recalculations for specific metals was not appropriate due to the species (*Daphnia magna*) selected for the WER and low hardness (<25) of site water (Tetra Tech, 2009).

The applicant selected a single sampling station 141, located on Middle Creek (2003) (see Figure 2), because this station is (1) closest to the proposed mine site, (2) is one of the current monitoring stations with a large record of water quality data, and (3) has water chemistry believed to be most representative of sub-drainages throughout the watershed. For additional information regarding the representativeness of Site 141 see Appendix A of this document. The body of evidence suggests the site water used for the WERs appropriately represents conditions in the three creeks and the Chuit River. Lone Creek (2004), Middle Creek (2003), and Bass Creek (2002) are adjacent tributaries with similar topography, similar watershed size, similar hydrology, and similar geological substrate (PacRim, 2009).

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In addition to having a high degree of geophysical similarity, the applicant compared the water chemistry of the three creeks and the river to the site water taken for WER samples to determine if the selected site water adequately represented the water chemistry in the creeks and river. Parameters monitored and analyzed were pH, alkalinity, total organic carbon, hardness, and specific conductivity.

Three rounds of WER testing were completed under three different flow regimes (ranging from high post storm flow to low base flow) to account for flow-dependent variability of selected water quality parameters, including organic carbon, hardness, and pH (PacRim, 2009).

The WER values were calculated in accordance with a study plan that was reviewed by DEC and EPA prior to the study's initiation. The WER geometric mean was selected as the proposed value to calculate SSC as recommended in the WER guidance documents (USEPA, 1994b and 2001). Table 4 summarizes the three rounds of WER testing, the results for each species, and the geometric means. The decision to apply the geometric mean rather than minimum WER value is the result of several factors including natural test variability, variation in site-water lethal concentration 50 (LC₅₀) values, and EPA guidance (EPA, 2001).

Table 4: Values for three rounds of testing. WER is the geometric mean. (PacRim, 2010)

Metal	Species	Round 1	Round 2	Round 3	Geometric Mean
Aluminum	<i>P. promelas</i>	7.11	2.68	22.00	7.48
Copper	<i>D. magna</i>	8.49	5.42	5.11	6.17
Zinc	<i>D. magna</i>	0.94	1.00	1.72	1.17

In addition to individual WER results a Mixed Metals Confirmatory Test was conducted to ascertain the degree of toxicity the metals posed when combined. This test was conducted using EPA guidance outlined in the *Water Effects Ratio (WER) Site-Specific Criteria Methodology* (USEPA, 1994). Prior to testing, PacRim/Tetra Tech predicted that there was a high likelihood that the metals would interact with one another as well as with dissolved organic matter present in the water column. These interactions would reduce the amount of

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dissolved metal that could be bioavailable and result in decreased toxicity to aquatic life. The results of the test demonstrated that there was no significant difference between the mixed metals test and the individual tests as determined by a statistical T-test. The results also validated the prediction as it was not possible to get the metals to dissolve out of concentration at a pH of 6.5, a pH value similar to that of the Chuit and its tributaries. Additional information and discussion about the confirmation test is located in Appendix B of this report.

Conflicting interpretation by DEC and EPA regarding the use of the mixed metals confirmatory test led to the solicitation of a third-party review (Solfield, 2014) of the individual and mixed metals WER reports and a professional opinion as to which values were most appropriate for consideration in the SSC process. The review was conducted by a professional environmental toxicologist who specializes in metals toxicology. The review consisted of an analysis of the individual and mixed metals study methodology, a review of the results and conclusions drawn, and professional opinion regarding how those results should be applied in the WER and SSC process.

The review concluded that the individual metals WER for aluminum, copper, and zinc were the appropriate values to apply for site-specific criteria. Additional information and discussion regarding the third-party review is located in Appendix C of this report.

iii. Proposed Site-Specific Criteria for Aluminum, Copper, and Zinc

Proposed aluminum SSC values

A geometric mean of individual metal tests results in a WER of 7.48 and a proposed SSC of 650 µg/L (chronic). Comparison of individual WER data with that of the confirmatory test indicate no significant difference between survival rates for the individual and confirmatory tests.

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Proposed copper SSC values

A geometric mean of individual metal tests results in a WER of 6.17 and proposed SSC of 17 µg/L (acute) and 22 µg/L (chronic) at a hardness of 25 mg/L. Comparison with the results of the confirmatory test indicate no significant difference between survival rates for the individual and confirmatory tests.

Proposed Zinc SSC values

A geometric mean of individual metal tests results in a WER of 1.17 and proposed SSC of 1.17 and subsequent SSC of 43 µg/L for both acute and chronic values at a hardness of 25 mg/L. Comparison with the results of the confirmatory test indicate no significant difference between survival rates for the individual and confirmatory tests.

The proposed SSC are summarized in Table 7. The proposed SSC are for fresh water acute and chronic criteria for aluminum, copper and zinc. These values will be referenced at 18 AAC 70.236(b) for the following 18 AAC 70.020(a) use classes:

- (1)(A)(iii) aquaculture; and
- (1)(C) growth and propagation of fish, shellfish, other aquatic life and wildlife.

Table 5. WER Results and Proposed Criteria

Metal	Water Effects Ratio	Alaska acute criteria ^{1,2}	Alaska chronic criteria ^{1,2}	Proposed acute site-specific criteria	Proposed chronic site-specific criteria
Aluminum (total recoverable)	7.48	750 µg/L	87 µg/L	NA ³	650 µg/L
Copper (dissolved)	6.17	3.64 µg/L	2.74 µg/L	17 µg/L	22 µg/L
Zinc (dissolved)	1.17	36.5 µg/L	36.5 µg/L	43 µg/L	43 µg/L

1. *Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances*, as amended through December 12, 2008
2. Calculated based on a hardness of 25 mg/l as CaCO₃. This value is representative of those found in the surface waters of the Chuitna basin during the summer low flow.
3. Acute SSC for aluminum are not proposed.

Downstream Protection of Designated Uses

To ensure compliance with 40 CFR 131.10(b) in all waters downstream of those proposed for SSC, PacRim conducted an analysis of whether proposed SSC would provide for the attainment and maintenance of downstream water quality standards (Tetra Tech 2013b). This approach considers the spatial extent of the proposed SSC and the assimilative capacity of downstream waters.

To conduct the loading analysis, Tetra Tech used all available sampling events with concurrent water quality and flow measurements at sampling stations both associated with the project drainages and the Chuit River. Figure 3 shows the stations and the drainages characterized.

Figure 3. Sampling Locations for Downstream Protection Loading Analysis

Station Number	Drainage	Description
45	Chuit River	Up River from Project Area
110	2004 - Bass Creek	Near Mouth of Drainage
120	Chuit River	Below 2004 Drainage
141	2003 - Middle Creek	Immediately Below Project Area
180	2003 - Middle Creek	Near Mouth of Drainage
220	2002 - Lone Creek	Near Mouth of Drainage
230	Chuit River	Down River from Project Area

To support the loading analysis, a graphical base flow separation analysis was applied to Station 230 on the Chuit River to characterize the type of flow regime that was being measured for each concurrent sampling event. Station 230 is located below Lone Creek (Figure 2) and considered to be representative of ambient water chemical characteristics in the lower reach of the Chuit River. Concurrent sampling events were classified as being one

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of three flow regimes: base flow, spring breakup and runoff, or rainfall generated storm flow. Sampling events, flow regime, and the measured flow at Station 230 are shown in Figure X.

Figure 4. Concurrent sampling events for Downstream Protection Loading Analysis

Station	Date	Flow Regime	Measured Flow (cfs)
230	10/5/2007	Storm Runoff	291
	2/9/2013	Base Flow	107
	5/11/2008	Spring Runoff	924
	8/3/2008	Base Flow	250
	9/24/2008	Storm Runoff	585

Aluminum results from Downstream Protection Loading Analysis

The results of the 2013 study determined that during baseline flow conditions, the load of total aluminum is naturally high in the Chuit River and associated tributaries (Tetra Tech 2013a). The analysis also demonstrated that aluminum concentrations will exceed the Alaska chronic aquatic life criterion during all storm and runoff events throughout the lower Chuit River basin. As a result the proposed SSC will include the lower Chuit River (between the confluence of Lone Creek and the tidewater terminus) as well as the three tributaries. This ensures that SSC will be representative of the existing ambient water quality during base as well as high flow conditions. Since marine criteria for aluminum do not exist, additional demonstration and consideration of downstream protection is not applicable.

Copper results from Downstream Protection Loading Analysis

The preliminary loading analysis used a broad conservative assumption that 50 percent of the total flow in project area streams would be from effluent discharges with dissolved copper concentrations at 95% of the proposed chronic SSC. The site specific criteria is based on a WER of 6.17. The water balance presented in the project's Water Management Plan was used to evaluate the initial assumption of 50 percent effluent discharge. This evaluation showed that project-associated discharges of effluent would be a much smaller

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proportion of the total stream flow under most flow conditions and would be a very small percentage of stream flow during high spring runoff and storm flow events. The loading analysis was then recalculated assuming that effluent discharges would be 20 percent or less during high spring runoff events and 45 percent or less during slightly smaller storm generated events (Tetra Tech 2013b). Based on these calculations, the downstream waters would be protected as the loading of copper in the Chuit River would meet Alaska water quality standards.

Zinc results from Downstream Protection Loading Analysis

Modeling results predict that zinc levels will remain within loading capacity and meet downstream Alaska water quality criteria if SSC are assigned to the three tributaries. This was demonstrated by modeled results using SSC at existing base and high flow conditions in the project area tributaries against existing downstream criteria in the Chuit River. The model included periods when a 50 percent effluent flow is applied. The model demonstrated that existing state water quality criteria were expected to be met at the confluence with the Chuit and additional demonstration of downstream protection is not required.

B. Manganese Site-Specific Criteria

Water quality data provided by PacRim (Tetra Tech, 2011a) indicates that elevated levels of naturally occurring manganese exist in the Chuit watershed including the three associated drainages. 300 individual surface water measurements of total manganese were taken in the watershed between 1982 and 2008 in the Bass, Middle, and Lone drainages (Riverside, 2009). Table 8 depicts how prevalent manganese is in the various drainages and the Chuit River. Of the 300 samples taken, approximately 56% were reported in excess of Alaska human health criterion for consumptions of water and aquatic organisms at 50 µg/L (or 0.05 mg/L) (PacRim, 2010a). Maximum values of over 100 µg/L were found in 15 of 22 stations, and over 200 µg/L at eight of 22 stations. PacRim has requested SSC relief for the Bass, Middle, and Lone Creek drainages as well as the lower reach (Bass Creek confluence to tidewater terminus) of the Chuit River.

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Table 6. Total Manganese present in samples collected at various locations within the proposed Chuit project area between 1982 and 2008 (Tetra Tech, 2011a)

Site ID ¹	Average Manganese value ²	Minimum value	Maximum value	Standard Deviation	N= Number of Samples
All Sites	80	10	350	60	298
Chuit River					
C020	20	10	20	10	4
C045	30	10	80	20	14
C120	50	10	210	40	29
Lone Creek (2002)					
C195	100	20	280	70	15
C196	70	20	140	40	9
C198	100	20	190	40	14
C200	70	30	110	20	5
C220	90	50	160	30	4
Q190	30	10	80	30	4
Q205	70				1
Q211	80	30	170	40	10
Middle Creek					
C128	140	40	310	80	14
C129	130	30	280	80	9
C140	150	70	290	90	5
C141	170	40	350	110	9
C180	80	30	200	40	29
Q170	100	50	150	40	8
Bass Creek					
C080	50	30	70	20	4
C110	50	30	110	50	14
Q050	30	10	70	20	14
Q383	110	50	170	40	8

¹ Sampling Locations are noted in Appendix A

² All values recorded in Total micrograms (µg/L)

i. Regulatory background

The Alaska human health criteria for manganese are based on the *Quality Criteria for Water (Red Book)* (USEPA 1976). EPA's Red Book suggests that the manganese human health criterion summarized in Table 9 for consumption of water and aquatic life was based on objectionable aesthetic effects (e.g. staining laundry) in drinking water. The criterion for

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consumption of aquatic organisms only was based on consuming shellfish from marine waters.

Table 7. Alaska Water Quality Criteria for Manganese

Protected Water Use Classes	2008 Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances
18AAC 70.020(a)	
(1) Fresh water	
(A) Water supply	
(i) Drinking, culinary, and food processing;	Human Health Criterion for Consumption of Water + Aquatic Organisms: 50 µg/L
(ii) Agriculture, including irrigation and stock watering	Irrigation Water Criterion: 200 µg/L
(C) Growth and propagation of fish, shellfish, other aquatic life and wildlife	Human Health Criterion for Consumption of Aquatic Organisms Only: 100 µg/L

ii. Evidence Supporting Site Specific Criteria Proposal

Drinking Water Advisory

Since the Red Book (EPA, 1976) was published, the scientific community has re-evaluated the relatively low toxicity of manganese as a lower public health concern (ATSDR, 2000; World Health Organization, 2004; USEPA, 2002a; USEPA, 2004). EPA published a Lifetime Health Advisory (HA) in 2004, which for manganese in drinking water for manganese at 300 µg/L (USEPA, 2004) that is protective of human health.

Methodology for Deriving SSC for Human Health.

In 2000 EPA published the *Methodology for Deriving Ambient Water Quality Criteria for the Protection of Human Health*, including procedures that could be used to derive a new criterion (USEPA, 2000). Alaska human health criteria for manganese are not based on human consumption of fish but rather were developed based on the consumption of shellfish as the most likely source of manganese. Site-specific research associated with the consumption of shellfish in the Chuitna Basin established that this area is not considered to be a subsistence harvest location for shellfish. Furthermore, blue mussels (*M. edulis*) collected in Cook Inlet (for the National Oceanic and Atmospheric Administration (NOAA) Mussel Watch

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program) indicated that manganese concentrations were at established at 8.5%-10.1% of allowable intake levels of 11mg of manganese per day.

DEC finds that the existing manganese criteria may be overly conservative and qualifies for SSC based on local fish and shellfish consumption information and naturally elevated concentrations of manganese reported in the Chuit watershed. DEC determined that the EPA's human health criteria methodology (EPA, 2000) was an appropriate means to derive SSC for manganese in Bass Creek, Middle Creek, Lone Creek and the lower reach of the Chuit River.

Derivation of Site-specific Criterion for Consumption of Aquatic Organisms Only¹

The criterion for consumption of aquatic organisms only was calculated using Equations 1 and 2 and the variables defined below these equations here:

Equation 1:

$$TRC = \frac{BW \times (RfD \times RSC)}{\sum_{i=2}^4 FI_i}$$

Equation 2:

$$WQC = \frac{TRC}{BCF}$$

Where:

TRC = Fish tissue residue criterion (mg Mn/kg fish) for freshwater and estuarine fish.

RfD = Reference dose (based on noncancer human health effects) of 0.14 mg/kg body weight per day (ATSDR, 2008)

RSC = Relative source contribution (fraction of the RfD to account for manganese from other sources). Value of 0.2 selected.

BW = Human body weight default value of 70 kg

FI = Fish intake at trophic level (TL) I (I =2, 3, 4). Site-specific value of 0.201² kg/fish/day selected.

¹ Methods used to derive Chuit SSC for manganese represent a case-specific situation and are not intended to establish a methodology for all human health criteria or other SSC in Alaska.

² 0.201 kg/day was derived from harvest data values collected for fish consumption rates of salmon (0.187 g/d) and non-salmon species (0.014).

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BCF = Bioconcentration factor. Site-specific value of 3.45 selected.
WQC = Water quality criterion

Using conservative assumptions for each input as described below, the SSC of .283 mg/L
(283) µg/L was calculated for consumption of aquatic organisms only.

RfD

The reference dose (RfD) for manganese of 0.14 mg/kg body weight per day (based on noncancer human health effects) is a standard value taken from the Agency for Toxic Substances and Disease Registry (ATSDR, 2008). EPA originally recommended that the RfD be reduced from 0.14 mg/kg to 0.05 mg/kg based upon the modifying factor of 3. However, in calculating the drinking water health advisory (EPA, 2004) EPA applied this modifying factor to the DI variable (shifting it from 2 L/day to 6 L/day). Based on this information DEC determined that the application of the modifying factor to the DI variable is more appropriate (See Equation 3) than modifying the RfD *and* the DI variable as the latter is considered to provide an overly conservative approach.

RSC

EPA recommends a relative source contribution (RSC) of 0.2 applied as a multiplier to the RfD rather than as a value (in this case 0) subtracted from the RfD (EPA, 2000). This default assumes consumers of fish from the Chuit River get 20% of their dietary manganese from consuming fish while other sources (e.g., refugia dust, other food sources) contribute the additional 80%. The use of a RSC of 20% is in keeping with the 2004 EPA drinking water health advisory and considered a conservative approach. This is also conservative based on harvest data collected by Alaska Department of Fish and Game (ADF&G, 2006).

FI

For the residents of Tyonek (the village closest to the Chuit), there are several fish intake (FI) rates that could potentially be used.

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- The default intake of fish used in the equations 1 and 2 is 0.0175 kg fish/day for the general adult population and 0.1424 kg fish/day for subsistence fishers based on EPA guidance (EPA, 2000).
- According to Alaska Department of Fish and Game (Stanek et al., 2007) residents of Tyonek, Alaska harvested 30,448 usable pounds of salmon in 2005/2006. During this period, salmon accounted for 69% of the harvest. The population of Tyonek at this time was 202 residents. Using these data and assuming equal distribution of fish consumption over 365 days, it was calculated that residents eat 0.187 kg salmon/person/day and 0.014 kg non-salmon fish/person/day for a total fish consumption rate value of 0.201 kg/fish/day. This value does not calculate fish waste or for harvested fish sent out of the area.
- DEC also reviewed information on Cook Inlet subsistence consumption that was in 2011-2012 and published in 2013 (Seldovia, 2013). The results revealed that the mean daily fish consumption rate for all Cook Inlet tribal members was 0.095 (\pm 23.5 SE) kg/fish/person/day with a 95th percentile consumption rate of 0.247 kg/fish/person/day. The mean unweighted fish consumption rate for the community of Tyonek was determined to be 0.063(\pm 19.6 SE) with a 95th percentile of 0.148 kg fish/day.

EPA comments suggest that a consumption rate of 0.201 kg/fish/person/day is appropriate for use in calculating a site-specific criterion for the Chuit (EPA, 2011). Based on these comments, DEC agrees to use the 0.201 kg/fish/person/day rate for developing SSC for manganese in the Chuit River and associated tributaries cited in this document.

The proposed fish consumption rate of 0.201 kg fish/day is considered acceptable by DEC since this value is larger than that documented for the village of Tyonek yet slightly more than the average rate of the EPA recommended subsistence consumption rate (0.1424 kg fish/day) and the Cook Inlet 95th percentile of 0.247 kg fish/day for the region. This value demonstrates a conservative assessment of fish consumption rate in the community as well as accounts for potential uncertainty in the regional study. This value only applies to the

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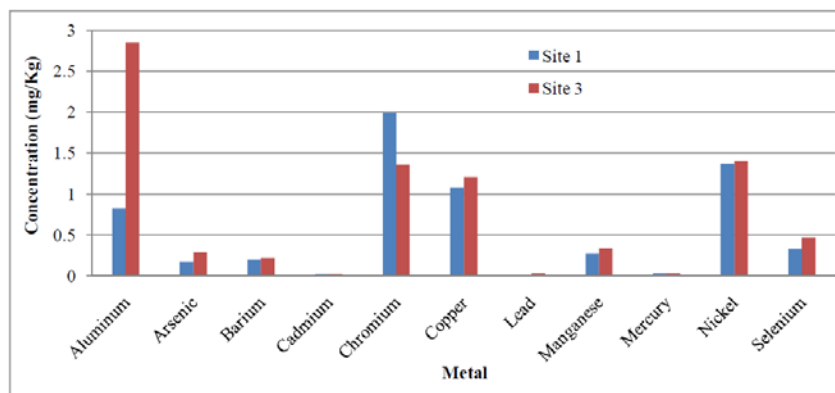
development of SSC for manganese for this specific project and should not be interpreted as a definitive fish consumption value for the Cook Inlet region or any other region in the State of Alaska.

Commented [TB1]: Please note this language. This is my attempt to ensure that the FCR values in this report are not considered to be DEC's recommended statewide FCR values

BCF

A site-specific bioconcentration factor (BCF) is required to convert the tissue residue criterion (TRC) into a WQC. PacRim collected age-1 juvenile coho (*Oncorhynchus Kisutch*) (n=200), sediment and water column samples (n=30), and adult salmon fillets (n=12) for tissue residue analysis in September 2009 from several different sampling locations within the proposed SSC area (PacRim, 2010b). The study results determined that the highest observed manganese concentration in a replicate fillet sample was 0.360 mg/kg (collected from site 110 at the confluence of the Chuitna and Lone Creek). The mean fillet manganese value for site 110 (Site 3) was 0.335 mg/kg and the value of the single replicate collected from site 180 (Site 1) was 0.270 mg/kg.

Figure 7: Bioconcentration values noted in Chuitna and Lone Creek (PacRim 2010b)



Using these values and the total manganese values (established as 0.06 mg/L at site 110 and 0.21 mg/L at site 180) observed at these sites at the time of salmon collection, the site-specific BCF values for salmon were established as 5.6 at Site 110 and 1.3 at Site 180.

Site 110: $0.335 \text{ mg/kg} / 0.06 \text{ mg/L} = 5.58$ (5.6) BCF

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Site 180: $0.270 \text{ mg/kg} / .21 \text{ mg/L} = 1.28 \text{ (1.3) BCF}$

The site-specific BCF is calculated as the mean of the two values (1.3 and 5.6), which results in a site-specific BCF of 3.45. These BCF values are representative of the exposure of salmon in the marine environment rather than exposure in the Chuit River (Tetra Tech, 2011a).

The BCF is applied as the bioaccumulation factor (BAF), the value used in Equation 3, as the manganese is present in its inorganic form and BAF/BCF is based on the wet weight of the fish tissue of the trophic level of concern. For inorganic chemicals, the baseline BAFs for trophic levels 3 and 4 are both assumed to equal the BCF determined for the chemical with fish, i.e., the BCF is assumed to be 1 for both trophic levels 3 and 4.

Derivation of Site-specific Criterion for Consumption of Water and Aquatic Organisms

Although these creeks are not used as a public water supply source, a site-specific criterion was developed based on consumption of fish as well as drinking water. This criterion was derived using EPA methodology (EPA, 2000) and Equation 3 below. The equation for calculating the manganese criterion for consumption of water and fish is as follows:

Equation 3:

$$WQC = RfD \times RSC \times \left(\frac{BW}{DI + \sum_{i=2}^4 (FI_i \times BAF_i)} \right)$$

Where:

- WQC = Ambient water quality criterion (mg /L)
- Rf/d = Reference dose (based on noncancer human health effects) of 0.14 mg/kg body weight per day (ATSDR, 2008)
- RSC = Relative source contribution (fraction multiplied by the Rf/d to account for contributions from other sources of Mn). Value estimated at 0.2, which is most conservative value used under drinking water program.
- BW = Human body weight default value of 70 kg

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- DI = Drinking water intake (2 L/day default). Value of 6 L/day selected following incorporation of the modifying factor of 3 suggested by EPA³.
FI = Fish intake at trophic level (TL) I (I = 2, 3, 4); Site-specific value of 0.201 kg/fish/day selected.
BAF = Site-specific bioconcentration factor (BCF) for salmon is 3.45 was selected.

The resulting criterion for the consumption of fish and water was calculated to be 0.293 mg/L. DEC has determined that adoption of the 0.300 mg/L (300 µg/L) was appropriate as 0.293 mg /L (293 µg/L) is not considered statistically different from EPA's lifetime health advisory for manganese at 300 µg/L (USEPA, 2004).

Protection of designated uses and downstream protection

To be added following additional discussion with PacRim. Expect to be conducting another loading analysis.]

iii. Proposed Site-Specific Criterion for Manganese

Human Health SSC:

DEC proposes SSC of 300 µg/L for manganese to protect human health for both consumption of water + aquatic organisms and for consumption of aquatic organisms only. This value is consistent with EPA's national drinking water lifetime health advisory. These SSC are presented in Table 8 and establish the manganese human health criteria included in 18 AAC 70.236(b) for the following 18 AAC 70.020(a) use classes:

- (1)(A)(i) drinking water, culinary, and food processing;
- (1)(A)(iii) aquaculture; and
- (1)(C) growth and propagation of fish, shellfish, other aquatic life and wildlife.

iv. Summary of Public Comments

[To be inserted after public comment period.]

IV. Conclusion

³ U.S. Environmental Protection Agency (2004) *Drinking Water Health Advisory for Manganese*. Pg.38

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DEC has reviewed information submitted by the applicant and researched other relevant available information in an effort to ensure the protection of existing and designated uses, provide for downstream protection of existing and designated uses, and provide the appropriate amount of relief when natural conditions exceed existing water quality criteria. As a result, DEC proposes to amend 18 AAC 236(b) by adding the subsections presented in Table 8.

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Table 8. Proposed SSC for Certain Waters in the Chuit River Watershed

18 AAC 70.236(b) WATERSHED TYPE/NAME NUMBER*		LATITUDE LONGITUDE **	LOCATION	REACH OF WATER AFFECTED	WATER QUALITY PARAMETER	DESIGNATED USE CLASS AFFECTED	SITE-SPECIFIC CRITERIA
(6) Bass Creek	19020602	61°08' 45" N 151°26' 55" W Set at the confluence with the Chuit River.	Tributary of the Chuit River near Tyonek	From the headwaters to the Chuit River confluence	Aluminum	(1)(A)(iii) (1)(C)	650 µg/l (chronic) measured as total metal
					Copper	(1)(A)(iii) (1)(C)	17 µg/l (chronic) 22 µg/l (acute) measured as dissolved metal
					Zinc	(1)(A)(iii) (1)(C)	43 µg/l (chronic) 43 µg/l (acute) measured as dissolved metal
					Manganese	(1)(A)(i) (1)(A)(iii) (1)(C)	300 µg/l (water and aquatic organisms) 300 µg/l (aquatic organisms only) measured as a total metal
(7) Middle Creek	19020601	61°07' 19" N 151°21' 15" W Set at the confluence with the Chuit River.	Tributary of the Chuit River near Tyonek	From the headwaters to the Chuit River confluence	Aluminum	(1)(A)(iii) (1)(C)	650 µg/l (chronic) measured as total metal
					Copper	(1)(A)(iii) (1)(C)	17 µg/l (chronic) 22 µg/l (acute) measured as dissolved metal
					Zinc	(1)(A)(iii) (1)(C)	43 µg/l (chronic) 43 µg/l (acute) measured as dissolved metal

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					Manganese	(1)(A)(i) (1)(A)(iii) (1)(C)	300 µg/l (water and aquatic organisms) 300 µg/l (aquatic organisms only) measured as a total metal
(8) Lone Creek	19020601	61°08' 45" N 151°18' 21" W Set at the confluence with the Chuit River.	Tributary of the Chuit River near Tyonek	From the headwaters to the Chuit River confluence	Aluminum	(1)(A)(iii) (1)(C)	650 µg/l (chronic) measured as total metal
					Copper	(1)(A)(iii) (1)(C)	17 µg/l (chronic) 22 µg/l (acute) measured as dissolved metal
					Zinc	(1)(A)(iii) (1)(C)	43 µg/l (chronic) 43 µg/l (acute) measured as dissolved metal
					Manganese	(1)(A)(i) (1)(A)(iii) (1)(C)	300 µg/l (water and aquatic organisms) 300 µg/l (aquatic organisms only) measured as a total metal
(9) Chuit River-Lower Main Stem	19020601	61°08' 45" N 151°18' 21" W Set at the confluence with Bass Creek.	Chuit River near Tyonek	From Confluence of Bass Creek to the tidewater terminus	Aluminum	(1)(A)(iii) (1)(C)	650 µg/l (chronic) measured as total metal
					Manganese	(1)(A)(i) (1)(A)(iii) (1)(C)	300 µg/l (water and aquatic organisms) 300 µg/l (aquatic organisms only) measured as a total metal

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Appendix A. Comparison of water chemistry in Lone Creek, Middle Creek, Bass Creek, and main stem Chuit for the purpose of conducting WER analysis

Introduction

PacRim Coal LP (PacRim) has proposed to the Alaska Department of Environmental Conservation (DEC) that SSC be developed for the main and lower stem of the Chuit River (20), Lone Creek (2002), Middle Creek (2003), and Bass Creek (2004) drainage(s)

(Figure 1.) This section addresses questions regarding the representativeness of the ambient source water collected and site water used to conduct Water Effect Ratio (WER) studies in support of the SSC request PacRim has submitted to DEC.

Analysis

The Chuit River, Lone, Middle, and Bass Creeks are all located in the same glaciated alluvial geological zone (Figure 1). All four watersheds contain surface geology of glacial alluvium with an underlying layer of sedimentary rock. The three drainages gently slope toward the Chuit River with moderate hills typical of glaciated landscapes (Riverside Technology Inc., 2007). Stream flow is similar to one another and subject to changes as the result of increased precipitation and interaction with shallow groundwater rather than seasonal variability. Flow is believed to be a significant influence on water quality chemistry as demonstrated by the relationship between Total suspended solids (TSS) to elevated concentrations of metals and elevated metal concentrations to occur during high stream flow events. TSS can also be indicator that high quantities of dissolved organic material (DOM) may be present. As DOM increases in waters, more metals would be expected to be bound to the dissolved organic carbon (DOC) component of the total DOM. However, as metals and other competing cations are added, beyond that of the existing binding site availability, less of the metals would be bound to the DOC and precipitation of insoluble, non-crystalline metals is expected to occur. Table A1 represents dissolved organic matter sampling taken between 1982 and 2008.

Table A1: Total Organic Carbon present in the Chuit Watershed. Riverside (2009)

Water body	Avg (mg/L)	Min (mg/L)	Max (mg/L)	# of samples	Period of record
Chuit River (20)	3	ND	24	36	1982-2008
Lone Creek (2002)	4	ND	10	38	
Middle Creek (2003)	5	2	9	33	
Bass Creek (2004)	5	ND	29	28	

The relationship between DOC and metal concentrations can be seen in site water sampling conducted for the individual WER tests. Table A2 demonstrates that (in general) as DOC values decrease, the dissolved concentrations tend to increase. This is attributed to surface runoff rather than anthropogenic sources.

Table A2: Site Water Values taken during (PacRim, 2010d)

--	--	--	--	--	--	--	--	--	--

Metal Concentrations of Site Water

Date Collected	Aluminum (mg/L)		Copper (mg/L)		Lead (mg/L)		Zinc (mg/L)	
	Total	Dissolved	Total	Dissolved	Total	Dissolved	Total	Dissolved
10/4/09	0.17	0.14	ND	ND	ND	ND	ND	0.039
10/25/09	0.089	0.082	ND	ND	ND	ND	ND	0.036
11/29/09	0.058	0.34	ND	ND	ND	ND	ND	0.81

PacRim Coal conducted two analyses to determine whether water chemistry was consistent across the four watersheds. The first study (Tetra Tech, 2009) compared existing historic water quality data across all stations in the Lone Creek, Middle Creek, and Bass Creek to the sample aliquots collected

for WER studies at Station 141 on the Middle Creek drainage. The second study (Tetra Tech, 2014) consisted of a comparison of site water from the Chuit River to that of the three drainages and Station 141. In both cases the results determined that the water chemistry was comparable from one drainage to another- thus demonstrating uniformity for WER results and SSC characterization purposes. The sample locations include:

Table A3: Sampling Locations

Station 45	Chuit River upstream of proposed project area
Station 110	Bass Creek near confluence with Chuit River
Station 120	Chuit River between confluence of Bass and Middle Creeks
Station 141	Middle Creek at the south end of the proposed project area
Station 180	Middle Creek near the confluence of the Chuit River
Station 220	Lone Creek near the confluence of the Chuit River
Station 230	Chuit River below proposed project area

Figure A3 illustrates the natural geochemistry across the four drainages and compares historic average water quality from sampling stations across the site using a Piper Diagram. Piper diagrams distinguish water quality type by plotting proportions of major cations versus major anions in different samples. The tight clustering of the sample plots in Figure 1 strongly indicates that the chemistry of the water occurring in the 2002, 2003, and 2004 drainages is very similar to that of the Chuit River and subject to similar ambient quality characteristics.

Additional testing conducted by Tetra Tech and PacRim Coal further analyzed the chemistry of site 141, 180, and 196 which were determined to have enough spatial variability to be representative of the entire area of concern. The water quality between the three stations is remarkably similar in concentration of parameters and behavior during low- versus high-flow conditions (PacRim, 2009).

Box and Whisker plots were also prepared to compare the chemistry of water collected from stations in the Main Stem (20 Drainage), Lone Creek (2002 drainage), Middle Creek (2003 drainage) and Bass Creek (2004 drainage) to each other and with sample aliquots collected at Station 141 to conduct WER Studies. Box and Whisker plots break sample populations into quartiles around the median (50th percentile). They also identify potential data outliers by plotting data that fall outside the first or fourth quartiles (triangle points). Box and Whisker plots identify the median (50th percentile) and potential outliers for pH, total alkalinity, specific conductivity, and hardness. An evaluation of these figures shows that for all four parameters, the sample populations have very similar data and that the samples

collected at Station 141 on Middle Creek (the 2003 drainage) for the WER study are representative of site water in all four drainages (PacRim, 2014).

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Figure A3. Piper Diagrams comparing major water quality geochemical parameters across all stations and sampling dates.

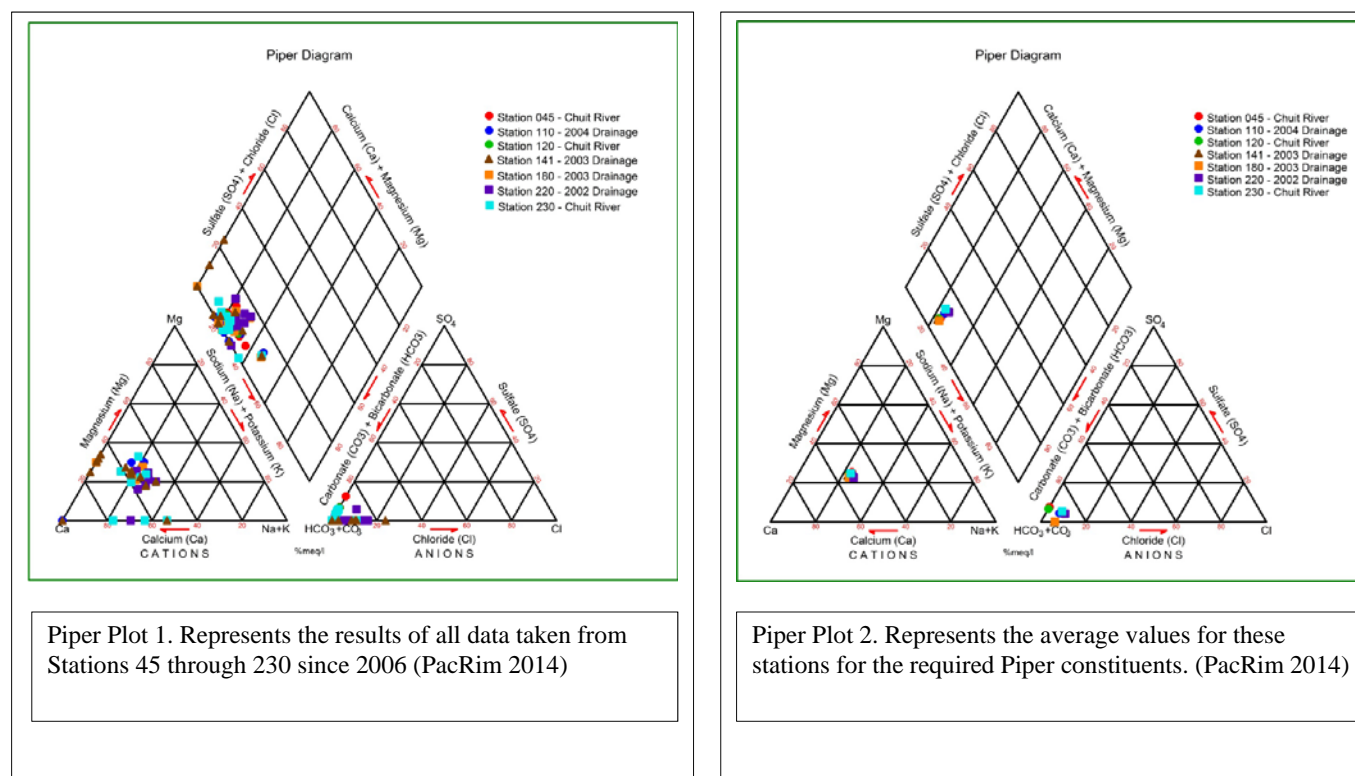


Figure A4. pH by Station (PacRim 2014)

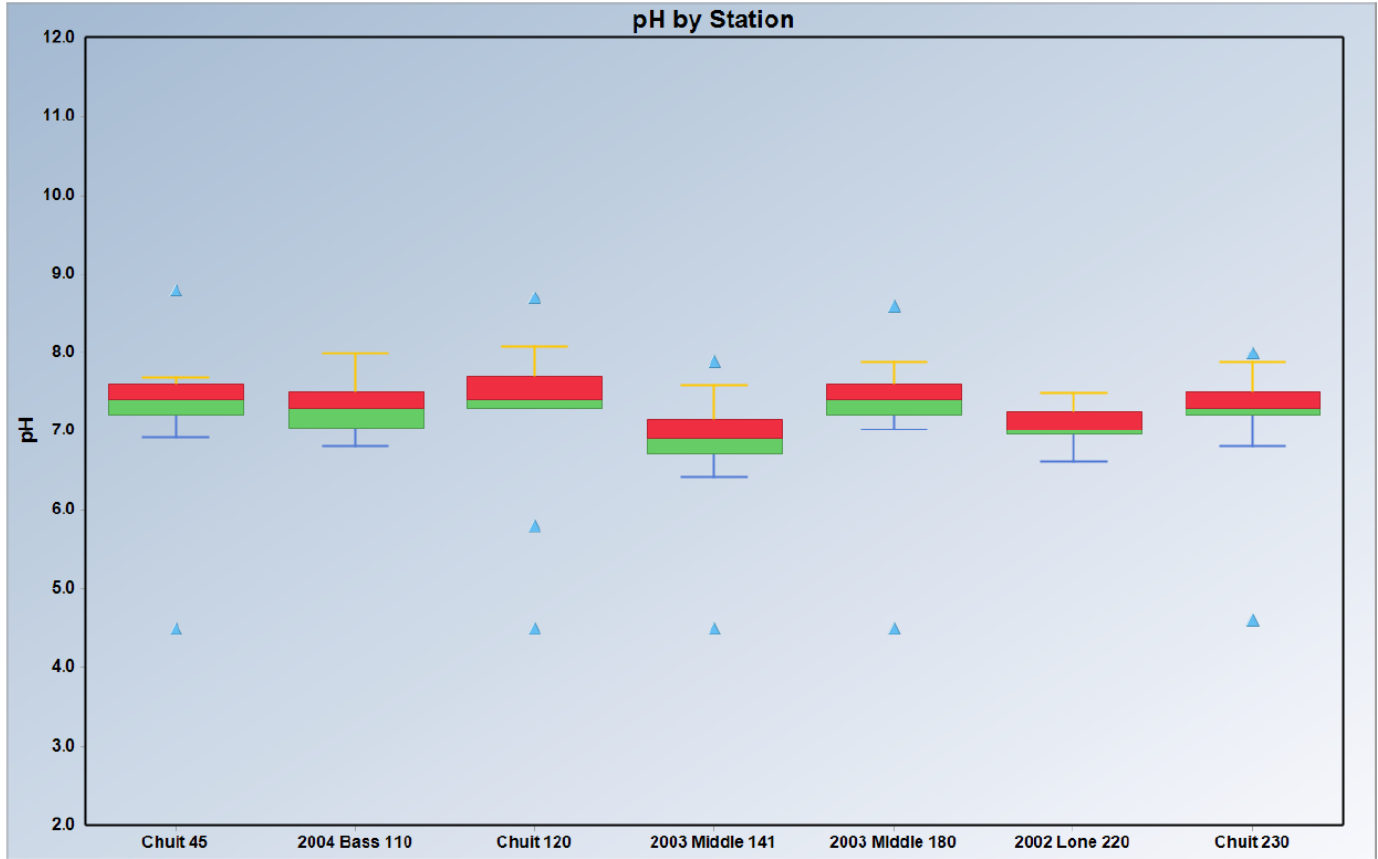


Figure A5. Total Alkalinity Concentration by Station (PacRim 2014)

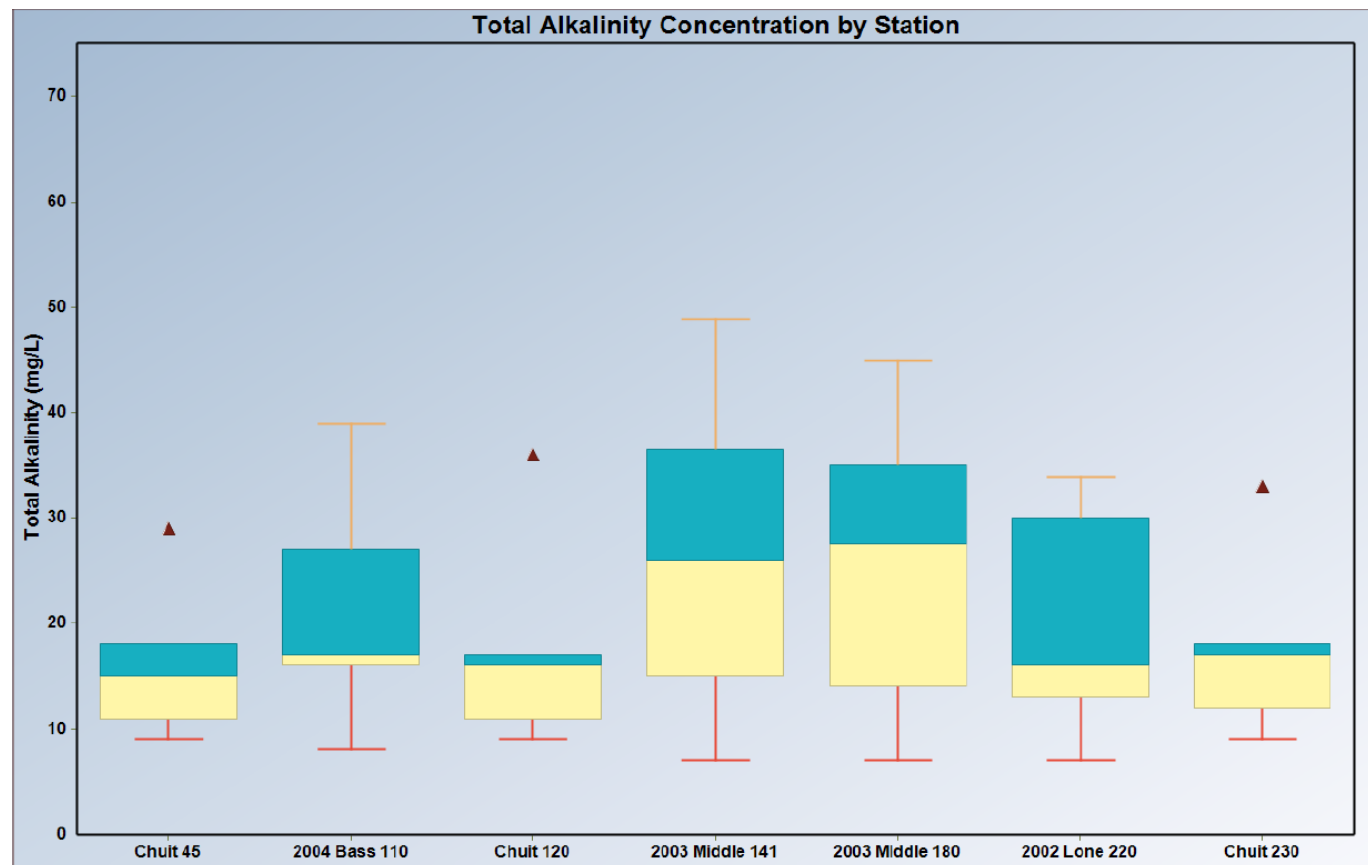


Figure A6. Specific Conductivity by Station (PacRim 2014)

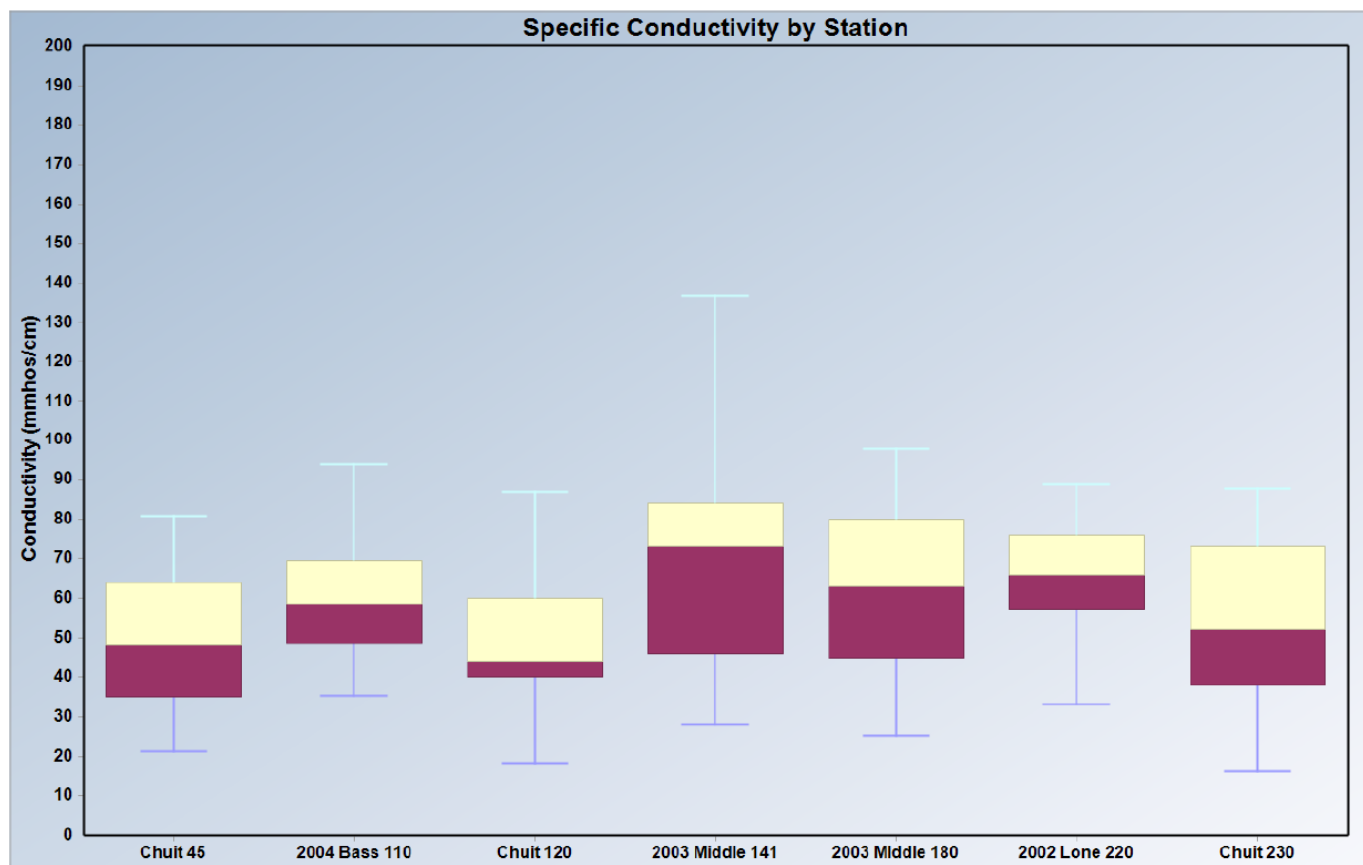


Figure A7. Hardness by Station (PacRim 2014)

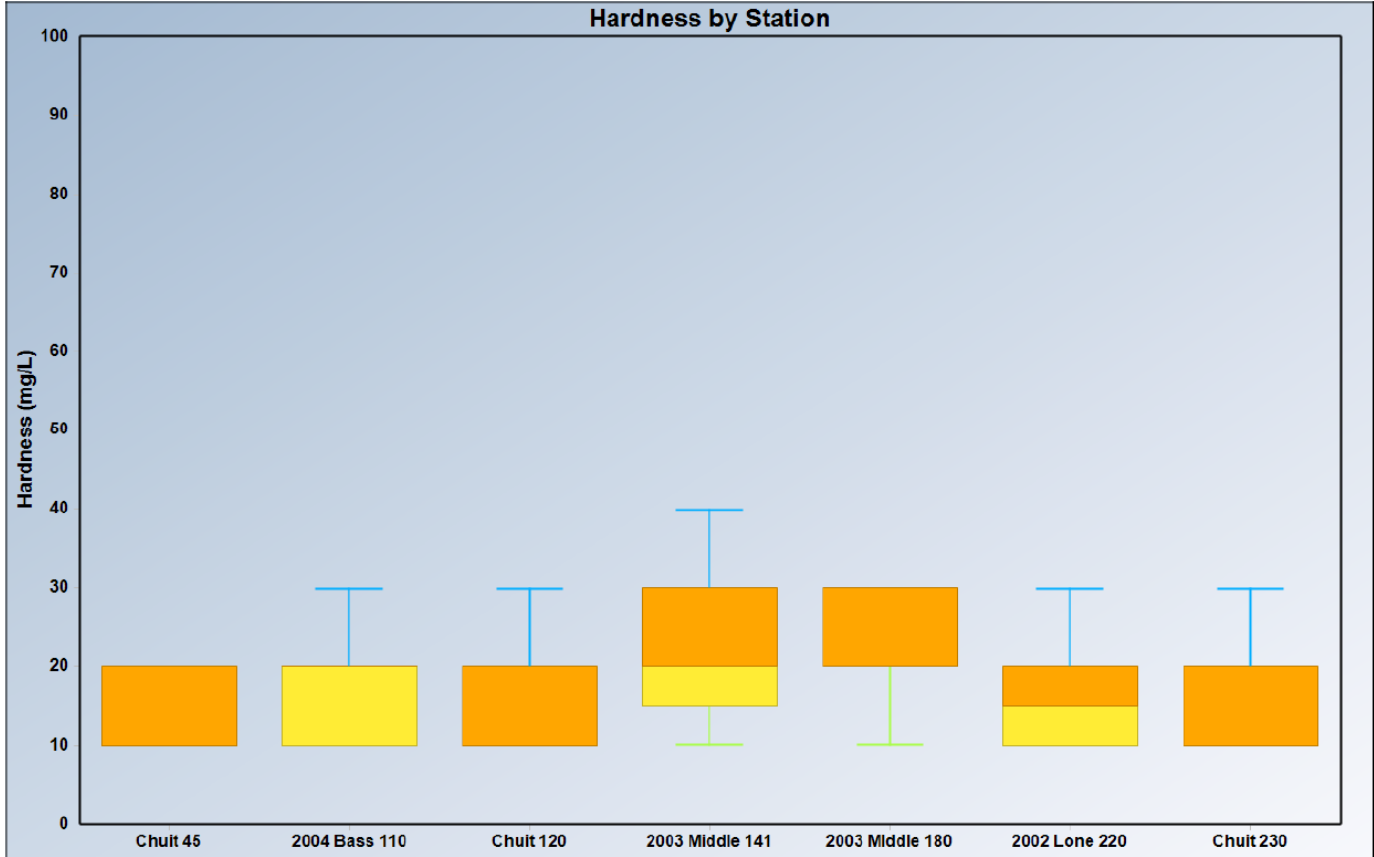


Table A4. Summary of general water quality parameters for C141 and other sites in the Chuitna Coal Operation area.

Parameter		C110	C129	C141	C180	C196	C220
pH	Average	7.5	7.5	7.4	7.5	7.4	7.5
	Maximum	7.9	7.8	7.7	8.0	7.8	7.7
	Minimum	7.0	6.8	6.9	6.5	6.8	6.4
Conductivity	Average	51.0	53.6	54.7	56.6	47.8	65.2
	Maximum	82.0	99.0	103.0	96.0	82.0	88.0
	Minimum	28.0	23.0	22.0	23.0	25.0	41.0
Hardness	Average	17.8	20	20	20	15.6	19.5
	Maximum	30	40	40	30	30	30
	Minimum	5	5	5	5	5	5
Alkalinity	Average	26.5	31.1	31.9	29.7	24.8	30.3
	Maximum	76	92	95	79	71	89
	Minimum	8	7	7	7	6	7
TDS	Average	43	53.3	60	71	70	76
	Maximum	70	70	100	190	210	210
	Minimum	30	40	30	40	30	40
TSS	Average	4.22	5.60	4.96	3.59	5.17	4.24
	Maximum	16	32.2	23	11	58	22
	Minimum	0.9	0.8	1.2	0.8	0.8	1.1
DO	Average	12.6	12.4	11.0	12.8	12.6	12.4
	Maximum	15.5	16.3	14.9	16.7	16.3	15.2
	Minimum	9.9	9.1	6.7	9.6	9.4	9.2

Table A5: Summary of metals present in surface water sampling (Riverside 2009)

Basin ¹	Parameter ²	Units	Average	Minimum	Maximum	No.	Record
20	Aluminum	mg/L	0.205	Non-detect	1.38	42	1982-2008
	Copper ³		0.00404		0.02	72	
	Manganese		0.02		0.04	72	
	Zinc		0.00676		0.05	72	
	CaCO ₃		15		30	44	
2002	Aluminum		0.145		1.2	44	
	Copper		ND		ND	73	
	Manganese		0.06		0.13	73	
	Zinc		0.00761		1.2	73	
	CaCO ₃		20		38	45	
2003	Aluminum		0.107		0.53	39	
	Copper		0.0036		0.01	67	
	Manganese		0.08		0.34	67	
	Zinc		0.0055		0.03	67	
	CaCO ₃		21		40	40	
2004	Aluminum		0.098		0.44	32	
	Copper		0.00408		0.001	32	
	Manganese		0.04		0.11	32	
	Zinc		0.00652		0.04	32	
	CaCO ₃		16		30	32	
40	Aluminum		0.227		0.9	20	1990-2008
	Copper		0.00218		0.002	20	
	Manganese		0.07		0.2	20	
	Zinc		0.007		0.024	20	
	CaCO ₃		21		60	20	

¹ Numeric values for basin correspond with names present in Section I (D) with the exception of 20 (Chuit River) and 40 (Threemile Creek).

² All parameters are reported in dissolved form with the exception of aluminum which is reported as total as the state water quality criteria is reported as total.

³ For samples collected prior to 2006, the detection limits for several trace metals were greater than the most stringent applicable water quality criteria. This includes copper.

Appendix B: Mixed Metals Confirmatory Test Results

At the suggestion of EPA and consistent with the *Water-Effects Ratio (WER) Site-Specific Criteria Methodology* (USEPA, 1994), a test was conducted using a mixture of the proposed WER metals (i.e., a multi-metal test). The multi-metal test evaluates the potential that multiple metals combined in solution at levels deemed non-toxic in single metal tests could have additive effects or interact with each other. Such cumulative and synergistic effects could potentially create greater toxicity than observed in the single metal WER tests. The 1994 guidance notes that⁴ “[E]ven when addition of two or more metals individually is acceptable, simultaneous addition of the two or more, each at its respective maximum acceptable concentration might be unacceptable for at least two reasons:

1. Additively or synergism might occur between metals.
2. More than one of the metals might be detoxified by the same complexing agent in the site water. When WER’s are determined individually, each metal can utilize all of the complexing capacity.

The 1994 guidance goes on to state that if individual WERs are used to demonstrate toxicity, then the results of combination tests must demonstrate acceptability as well. The guidance also notes that “It is possible that a toxicity test used as the primary test for one metal might be more sensitive than the criterion maximum concentration (CMC) or criterion chronic concentration (CCC) of another metal and thus might not be useable in the confirmation test”.

Tetra Tech prepared a test procedure that was reviewed by EPA and DEC (Tetra Tech, 2011b). Test procedures used are outlined in Tetra Tech’s 2011 memorandum. Prior to initiating the multi-metals test DEC, EPA, and Tetra Tech acknowledged that there was a high likelihood the metals could interact, resulting in some of the metal precipitating out of solution. The metals did precipitate as predicted causing the tests to be conducted at dissolved concentrations less than the proposed SSC based upon individual WER tests. While these solubility interactions make it impossible to determine toxicity in a multi-metals test at the proposed concentrations, the tests do provide important information. The multi-

⁴ USEPA 1994. Appendix F. pg. 135

metals test indicated that at neutral pH, these metals would precipitate similarly in the creeks to levels seen in the multi-metal test. Concentrations for the multi-metals test are shown in [Table B1](#).

Table B1. Summary of site-specific acute criteria (µg/L) for each metal at similar concentrations from WER study, current state criteria, and SSC and the resulting total metal concentration in sample needed to achieve dissolved metal goals assuming total/dissolved metal ratios remain the same as in single-metal tests (Tetra Tech, 2012)

	Proposed Site Specific Acute Criteria µg/L	Total Concentration used in mixed test µg/L with <i>D.Magna</i>	Percent Acute SSC Concentration	Multi- Metals Measured Concentration µg/L	Alaska Chronic Criteria µg/L ¹	Proposed Site-Specific Chronic Criteria µg/L
Aluminum ²	NA	700	NA	NA	87 (total)	650 (total)
Copper ³	22	35.5	152%	36 (total) 15.1 (dis.)	2.74	17(dissolved)
Zinc	43	65.3	155%	60 (total) 30 (dis.)	36.5	43 (dissolved)

1. Copper and zinc criteria were based on a hardness of 25 mg/l as CaCO₃.
2. Aluminum criteria are total recoverable in Alaska's water quality standards.
3. Proposed SSC for copper adjusted to the mean dissolved concentration in the mixed metals test.
4. Predicted total recoverable concentrations of each metal that would theoretically be needed to achieve proposed SSC concentrations based on dissolved metal water effect ratios determined by Tetra Tech in previous testing (Tetra Tech, 2010).

Water chemistry parameters for the site water used for the confirmatory metal mixture testing. Sample shipped Dec 7, 2010. Sample collected at site 141. (Tetra Tech 2011b)

Table B2. Site Water Characteristics

Parameter	Check In Measurement
Dissolved oxygen (mg/L)	14.2
Temperature (°C)	11.1
pH (su)	7.3
Conductivity (us/cm)	46.4
Chlorine (mg/L)	ND (<0.01)
Ammonia (mg/L)	0.03
Hardness (mg/L as CaCO ₃)	38
Alkalinity (mg/L as CaCO ₃)	14

The multi-metal confirmation testing began in December, 2010. A grab sample was collected from Chuitna site 141, the same location as the previous WER tests (Tetra Tech, 2011b) in

an effort to assure representativeness. Knowing the total and corresponding dissolved concentrations for each metal in site water multi-metal testing, it is possible to predict the total concentration of each metal that would theoretically be needed to achieve dissolved metal concentrations equivalent to the proposed SSC, which are based on dissolved metal WERs. All methods followed USEPA protocols used in WER testing (USEPA 2002). The test results reported by Tetra Tech were for the acute tests on *P. promelas* and *D. magna* (Table B3 and B4).

Results

The total metal concentrations used in the multi-metal testing were in excess of the proposed criteria (expressed as a total fraction) by 152% (copper) and 155% zinc). The reasoning for using elevated levels was to maintain the total to dissolved ratio goals set in the individual WER tests (Tetra Tech, 2011b). Thus, the dissolved fraction for each of the metals, under actual site conditions, are expected be less than what was achievable in the test because the same interactive chemical factors would apply due to the presence of dissolved organic matter. All the metals tested are relatively insoluble when combined at neutral pH. In fact, it is chemically not possible to manipulate the site water in a reasonable manner (i.e., without reducing the pH to very acidic and toxic levels) to achieve the dissolved criteria goals for these metals in combination (Tetra Tech, 2011b). The mean survival rates at the multi-metal test concentrations in spiked site water were 85% and 97.5% for *D. magna* and fathead minnow respectively (Table 2 and 3). The survival rates of the laboratory control tests were 95% and 100%. The spiked samples tested with both *D. magna* and fathead minnows represented the worst-case scenario for these reasons: This evaluation demonstrates the conservatism of the multi-metal test compared to actual conditions that could occur in receiving waters should the WER based criteria be adopted (Tetra Tech, 2012).

Table B3. Summary of the proposed metals criteria, WER tested concentrations, and survival of *Daphnia magna* test species in acute exposures.

Sample	Mean Survival	Metal	Total Recoverable acute criterion (ug/L)	Measured total recoverable (ug/L)	Measured value as % of total criterion	Dissolved acute criterion (ug/L)	Measured dissolved (ug/L)	Measured value as percent of dissolved criterion
Laboratory Control	95%	Al	750.0	5.0	0.7%	NA	10.0	NA
		Cu	37.7	4.1	10.7%	36.2	0.5	1.4%
		Zn	61.8	2.5	4.0%	60.4	2.5	4.1%
Site	100%	Al	750.0	232.5	31.0%	NA	49.0	NA
		Cu	37.7	0.8	2.1%	36.2	1.5	4.1%
		Zn	61.8	5.1	8.3%	60.4	6.8	11.3%
Spiked site	85%	Al	750.0	700.0	93.3%	NA	0.1228	NA
		Cu	37.7	35.5	94.2%	36.2	14.5	40.1%
		Zn	61.8	65.3	105.7%	197.2	30.8	50.9%

Table B4. Summary of the proposed metals criteria, WER tested concentrations, and survival of fathead minnow test species in acute exposures.

Sample	Mean Survival	Metal	Total Recoverable acute criterion (ug/L)	Measured total recoverable (ug/L)	Measured value as % of total criterion	Dissolved acute criterion (ug/L)	Measured dissolved (ug/L)	Measured value as percent of dissolved criterion
Laboratory Control	100%	Al	750.0	5.0	0.7%	NA ¹	5.0	NA
		Cu	37.7	0.8	2.0%	36.2	0.5	1.4%
		Zn	61.8	2.5	4.0%	60.4	4.3	7.0%
Site	97.5%	Al	750.0	320.0	42.7%	NA ¹	46.0	NA
		Cu	37.7	0.5	1.3%	36.2	0.5	1.4%
		Zn	61.8	3.2	5.2%	60.4	4.5	7.4%
Spiked site	97.5%	Al	750.0	662.5	88.3%	NA ¹	118.0	NA
		Cu	37.7	37.8	100.2%	36.2	15.8	43.5%
		Zn	61.8	67.8	109.7%	60.4	34.8	57.5%

1. Acute criteria for aluminum are not being proposed. The statewide criteria of 750 µg/L will still apply.

Conclusion

DEC concluded that the mixed metals confirmatory test was successful and that no statistically toxic impact is posed at the proposed metal concentrations. This is based on the following:

- The total metal concentrations in the spiked site water test were the same as the dissolved concentrations in individual tests. Metals were added to the site water in a highly soluble ionic form.
- The total copper and zinc concentrations would need to be more than double the proposed total criterion using the total to dissolved ratio determined from the individual tests.
- It was not possible to get the metals to dissolve using the multi-metals mixture at a pH of 6.5, similar to ambient conditions in the creeks and river. Due to the pH and natural ligands in the site water, the metals would naturally precipitate in the creeks at the concentrations used in the multi metal test.
- The solutions were shown to be non-toxic to both test species used in both the individual and mixed metals confirmation tests

DEC believes that the data from this test should be used to complement the individual WER test values when determining SSC for the Chuit project rather than act as the primary WER values in the SSC formula. For additional information see Appendix C of this report.

Appendix B References

Tetra Tech Inc. December 1, 2010 Memorandum. The use of site-specific total: dissolved metals ratio to determine appropriate metals concentrations for use in confirmatory testing.

Tetra Tech Inc. January 7, 2011b. Results of Confirmatory WER Mixture Testing. Memorandum from Henry Diamond and Henry Latimer to Dan Graham, PacRim Coal.

Tetra Tech Inc. August 2012. Memorandum. Additional discussion for WER mixture testing.

U.S. Environmental Protection Agency 1994b. Interim Guidance on Determination and Use of Water Effect Ratio for Metals. EPA-823-B-94-001. Office of Water, Washington, D.C.

U.S. Environmental Protection Agency. 2002b. National Recommended Water Quality Criteria 2002. EPA-822-R-02-047. Office of Water, Washington, D.C.

Appendix C: Analysis of Individual and Confirmation (mixed metals) Testing Results

In an effort to determine whether the individual WER or mixed metal WER results were the most appropriate values to consider in the SSC process, DEC recommended additional review of the individual and mixed metals data provided by PacRim to be conducted by an independent toxicologist. The value of the additional analysis was to:

- provide DEC with an additional informed opinion;
- evaluate any potential bias in the original data and report incorrect conclusions that may have unknowingly taken place during Tetra Tech's analysis; and
- ensure transparency during the SSC proposal process.

Two primary objectives were established for the analysis:

Objective 1. Expert review of the Water Effects Ratio (WER) studies (original and mixed metal confirmation tests) for the SSC, review of the Alaska Department of Environmental Conservation (DEC) analysis of the WER studies, and review of Region 10 EPA's analysis and comments of the studies.

Objective 2. Provide a response as a technical professional opinion of the following key questions:

- a) Is it appropriate to use the mixed metals Confirmatory tests to derive chronic criteria (as Region 10 EPA suggests) given the chemistry and precipitation problems associated with this test? As described by PacRim Coal "Aluminum makes this approach especially problematic since the original criteria was developed under different pH and hardness conditions and with different species than were used in the mixing metals test. Aluminum also complicates the chemistry for copper in the mixing metals test."
- b) Does the methodology allow the use of individual WER test to derive the site specific criteria, even if the mixed metals Confirmatory tests did not have metals concentrations as high as the individual WER tests?

Ruth Solfield, PhD, was solicited for this project by PacRim and approved of by DEC due to her experience in the field to aquatic toxicology and expertise in metals analysis. Her analysis consisted of a review of the results of the individual WER tests, review of the multi-metals confirmation tests, review of PacRim-supplied supporting documents, review of EPA-provided informal comments, and review of DEC's preliminary draft decision document.

Evaluation of Individual Metals WER

The analysis of the individual WER test(s) determined that the test was of good design and followed accepted methodology. While some minor irregularities were noted (i.e., issues with species mortality in the controls) it was determined that this did not compromise the WER results as a whole and that the individual WER values were appropriate for recalculating site-specific acute and chronic criteria in a dissolved form for aluminum, copper, and zinc.

Evaluation of Multi-metals Confirmatory Testing WER

The analysis considered several documents associated with the multi-metal confirmatory test and determined that the test was conducted in accordance to USEPA (2002) guidance. The analysis noted that there was a decrease in the ratio between the dissolved and total fractions of copper and zinc indicating a smaller percentage of the metals remained in dissolved form in site water versus that of laboratory water. The analysis concluded that site water physicochemical properties will cause lowered solubility when the metals are combined. This was based on a decrease in the ratio of dissolved to total metal concentration in the multi-metal spiked site water in the confirmatory test compared to the ratios in the individual metal spiked site water in the WER tests. The decrease is attributed to the presence of dissolved organic carbon (DOC) as higher levels are expected to allow for increased binding of metals. However, as metals and other competing cations are added, beyond that of the existing binding site availability, the total amount of metal available would decrease and precipitation of excess insoluble, non-crystalline metals is expected to occur. These outcomes had been predicted by PacRim/Tetra Tech prior to conducting the mixed metals confirmatory tests. Data on ambient total organic carbon levels is located in Appendix A.

In order to better understand the types of interactions that may be occurring in the site waters that could affect the concentrations of the dissolved fractions of the metals and in turn, the potential toxicity of the site water to aquatic life, the Stockholm Humic Model was used. Dr. Solfield and DEC note that the modeling exercise was not meant to reflect actual conditions in the Chuit River, rather the models were designed to show how the presence of multiple metals can affect speciation and resultant toxicity.

The model predicted that 99.988% of metals would precipitate out when aluminum, copper, and zinc were combined at the proposed total values. Zinc and aluminum were predicted to be the most likely metals to precipitate out of the solution in the presence of other metals as copper and lead out-compete the zinc and aluminum for binding sites. The same results were predicted by Tetra Tech prior to undertaking the confirmatory multi-metal test (Tetra Tech, 2011b).

An assessment of the Toxic Units was also conducted, to provide a consistent comparison of individual WER tests against the confirmatory toxicity test results using the same hardness. Toxic units are the measure of toxicity in an effluent as determined by the acute toxicity units (TUa) or chronic toxicity units (TUc) measured. Total Toxic Units (TTU) were calculated for the confirmatory multi-metal test for *D. magna* and *P. promelas*. The dissolved and total metal concentrations measured in the site water from the confirmatory test were compared to either the toxicity results from the WER tests using individual metal toxicity for each round in the site water or to the acute aquatic life criteria in Alaska water quality standards. The copper, lead, and zinc criteria and LC50s from the individual metals tests were hardness adjusted to 38 mg/L to match the water hardness of the site water in the confirmatory test using equations in the *Alaska Water Quality Criteria Manual* (ADEC, 2008) used to calculate hardness-dependent criteria and for the LC50 corrections. The results indicated less than 50 percent mortality (i.e. no significant toxicity measured) took place when comparing dissolved against total metals concentrations in the individual WERs. Similar mortality results were also noted when comparing the values of confirmatory tests against the existing state criteria despite a 4.34 to 23.05 factor increase in concentration.

Conclusion

The analysis of the individual and mixed metals data resulted in similar conclusions to that of PacRim/Tetra Tech and DEC. The individual WER results are considered to be the more appropriate of the two sets of values as determined by aquatic survival rates in each of the tests, assessment of the statistical evidence conducted by Tetra Tech in the confirmatory test, and assessment of the toxic units between the two tests. It was determined that the mixed metals test has no predictive ability and that additive behavior, leading to deceased toxicity was likely to take place.

Guidance provided by USEPA (1994) supports this finding as, “If a WER is determined for each metal individually, one or more additional toxicity tests must be conducted at the end to show that the combination of all metals at their proposed new site specific criteria is acceptable.” Solfield interprets “at their proposed new site specific criteria...” as an indication that the site specific criteria will have been proposed prior to conducting the Confirmatory tests (using the single metals tests in the Chuit River case), so that modifying criteria again based on results of the Confirmatory test is not necessary or required. DEC concurs with this opinion.

Appendix C References

ADEC. 2008. Alaska Water Quality Criteria Manual for Toxic and Other Deleterious Organic and Inorganic Substances. State of Alaska, Department of Environmental Conservation.

Solfield, Ruth. 2014

Tetra Tech Inc. January 7, 2011b. Results of Confirmatory WER Mixture Testing. Memorandum from Jerry Diamond and Henry Latimer to Dan Graham, PacRim Coal

USEPA. 1994. Interim Guidance on Determination and Use of Water-Effect Ratios for Metals. U.S. Environmental Protection Agency, Office of Water: EPA-823-B-94-001.

USEPA. 2002. Methods for Measuring the Acute Toxicity of Effluents and Receiving Waters to Freshwater and Marine Organisms, 5th Edition. U.S. Environmental Protection Agency, Office of Water: EPA-821-R-02-012

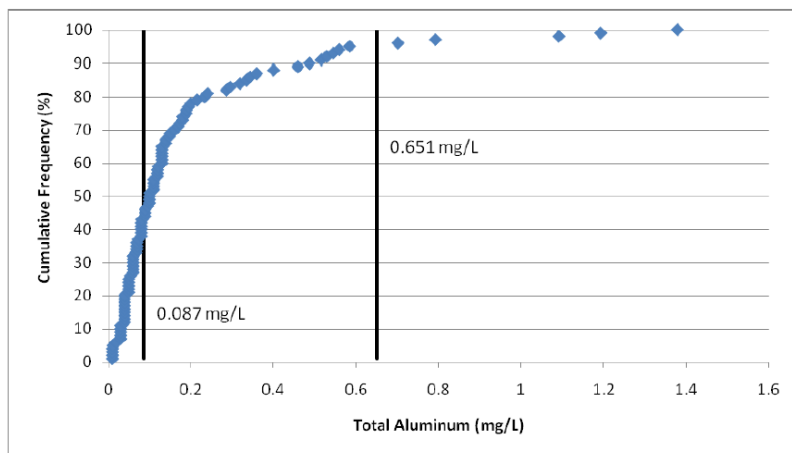
Appendix D: Aluminum (Total and Dissolved) Relationship between TSS and Flow

The toxicity of aluminum is highly dependent of the chemical species present and the bioavailability to fish and other aquatic species. The following reviews the characteristics of aluminum present in the Chuitna River and tributary creeks. Given that there are no chemical treatment of the discharge from the Chuitna Coal mine, the aluminum present in the discharge and receiving waters is likely to maintain same the characteristics and chemical species of aluminum regulated under the proposed SSC.

Background

Between July 2006 and September 2008 (164 total measurements), the observed concentration of total aluminum in the Chuitna Basin ranged from less than detectable (20 µg/L) to a maximum of 1,380 µg/L with a median value of 100 µg/L (Figure D1). Based on this data, under natural concentrations in the basin exceed the Alaska chronic water quality criterion of 87µg/L (total recoverable aluminum) in 66% of the samples.

Figure D1: Cumulative frequency distribution of total aluminum (mg/L) concentrations observed in the Chuitna Basin. The current (0.087 mg/L) and proposed (0.651 mg/L) chronic aluminum standards are represented by vertical lines. (Tetra Tech 2013a



¹ Tetra Tech 2013a. Technical Memorandum. Water Quality and Geochemical comparisons of surface water quality for water quality stations in the 2002, 2003, and 2004 drainages. April 2013

Further evaluation of background ambient water quality demonstrates the prevalence of aluminum across the different watersheds as well as being directly associated with flow conditions. A study of baseline loading of total aluminum concentrations in the Chuit and associated tributaries indicate that aluminum concentration increases when sediments in the substrate are entrained during moderate to high velocity flows (i.e. storm generated runoff or snowmelt). During these periods, the chronic standard of 87 µg/L was exceeded in all three creeks and the river. Aluminum is often associated with sediments and is a major element in most types of clay minerals. It is hypothesized that increases in aluminum concentrations in both the river and the tributary creeks are associated with clay fractions in entrained sediments (i.e. suspended solids) (Tetra Tech 2013a).

Aluminum Statistical Evaluation

PacRim and Tetra Tech provided two statistical analysis to evaluate this hypothesis. A One-Way Analysis of Variance (ANOVA) was used to compare water quality data for total aluminum across Stations 45, 110, 120,141, 180, 220, and 230. These stations are considered to be representative of the water quality of all four watersheds. As can be seen from the ANOVA table, the calculated F statistic (0.78) is very low in comparison to the critical F value (2.25). This results in a very high p-value (0.59). In effect, this analysis shows that there is no significant difference in measured total aluminum across all stations. These data further demonstrate that water quality throughout the watershed is similar with respect to total aluminum concentration and variance.

Figure D2. Summary statistics for total aluminum calculated by the ANOVA analysis (Tetra Tech, 2014)

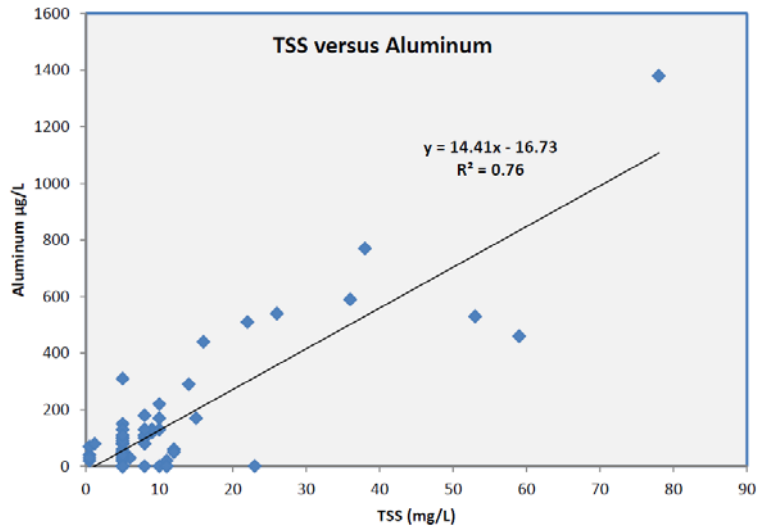
<i>Groups</i>	<i>Count</i>	<i>Sum</i>	<i>Average</i>	<i>Variance</i>
Chuitna 45	10	2,250	225	144,028
Chuitna 120	10	1,980	198	59,973
Chuitna 230	10	2,960	296	184,204
2004 Bass 110	10	1,170	117	16,823
2003 Middle 141	10	1,390	139	20,766
2003 Middle 180	10	940	94	2,938
2002 Lone 220	10	1,370	137	24,157

Figure D3. ANOVA statistical results

Source of Variation	SS	df	MS	F	P-value	F crit
Between Groups	302,834	6	50,472	0.78	0.59	2.25
Within Groups	4,076,000	63	64,698			
Total	4,378,834	69				

To test whether total aluminum and TSS could be correlated, a least squares regression analysis was applied. A strong correlation was demonstrated between measured total suspended solids (TSS) and total aluminum concentration. The coefficient of determination (r^2) of 0.76 means that 76 percent of the variation in aluminum concentration in the watershed can be explained by the variation in TSS using the derived equation. An evaluation of data points in this plot further confirms the conclusions from the loading study that show increasing loading of aluminum with when the stream and river flows increase above basic base flow conditions. Increased flow velocities entrain sediments from the substrate. These data strongly suggest that aluminum is associated with these sediments, potentially as clay or at least as part of mineralogy in the system.

Figure D4. Least squares regression analysis between total aluminum and TSS (Tetra Tech, 2014)



At the request of DEC, further analysis of the relationship between total and dissolved Al bioavailable in the Chuit system was conducted. Using data collected at various flow regimes, the following was determined:

- The increase in TSS is associated predominantly with increases in flow (i.e. storm events);
- The increase in TSS also correlates with the increase in total aluminum in the system, indicating it is associated with the sediment; and
- The increase in total to dissolved ratio with increases in TSS confirms that the added aluminum at the higher TSS is attributable to the sediment and does not increase the dissolved portion proportionately (PacRim March, 2014).

TSS versus Total Aluminum/Total versus Dissolved Aluminum

Regression analysis of the data collected between Station 45, 120, and 230 (See Figure D2) indicate that an increasing correlation between total aluminum and TSS exists in the upstream to downstream flows. The regression correlation (R²) increases from very low at Station 45 (0.13) to moderate at Station 120 (0.70) to high at Station 230 (0.91). Figures 1 through 3 demonstrating this relationship are available in Appendix C. The results indicate a clear increase in correlation between TSS and total aluminum as you proceed downstream into the area being requested for SSC coverage.

Comparisons of total to dissolved aluminum demonstrated that the ratio of total aluminum to flow is more conclusive than that of dissolved aluminum to flow. The ratio of total to dissolved ranges from 1:4 at low flows while higher flows result in a maximum range of 29:1 above the proposed project area to 46:1 below the confluence of Lone Creek (2004). Based on this information DEC has concluded that the bioavailability of aluminum is directly tied to TSS in the form of clay particulate and unavailable in amounts considered toxic to aquatic life.

Background studies and statistical analysis demonstrate that all waters considered for proposed SSC are chemically similar in regards to aluminum as well as subject to the same flow to TSS relationship. Based on these conclusions, application of the individual WER results for aluminum to the Chuit River, Bass Creek, Middle Creek, and Lone Creek is

appropriate and meets the required demonstration for site specific criteria in Alaska Water Quality Standards and EPA guidance.

Figure D5. TSS to Flow results with Aluminum total/dissolved values by monitoring station.

Table 1. Station 45 - Main Stem Chuitna above Bass Creek

Date	Flow cfs	TSS mg/L	Al - Total µg/L	Al - Dissolved µg/L	Ratio Al _T /Al _D
7/3/2006	NA	< 5	40	< 20	2.0
8/21/2006	182	5	90	30	3.0
2/23/2007	24	< 5	< 20	< 20	1.0
5/23/2007	442	36	590	40	14.8
7/25/2007	85	12	60	< 20	3.0
10/4/2007	141	< 5	80	< 20	4.0
2/9/2008	37	5	< 20	< 20	1.0
5/11/2008	340	7.7	1,190	40	29.8
8/3/2008	167	6	30	< 20	1.5
Count	8	9	9	8	9
Average ¹	177	10	236	26	6.7
Min	24	5	20	< 20	1.0
Max	442	36	1,190	40	29.8

NA - Data not available or not measured

Table 2. Station 120 - Main Stem Chuitna between confluence with Bass and Middle Creek

Date	Flow cfs	TSS mg/L	Al - Total µg/L	Al - Dissolved µg/L	Ratio Al _T /Al _D
7/2/2006	NA	< 0.5	40	< 20	2.0
8/23/2006	NA	14	290	60	4.8
2/24/2007	NA	< 0.5	< 20	< 20	1.0
5/23/2007	NA	38	770	30	25.7
7/25/2007	NA	9	130	< 20	6.5
10/4/2007	205	< 0.5	70	< 20	3.5
2/9/2008	72	5	40	< 20	2.0
5/11/2008	479	59	460	50	9.2
8/3/2008	201	< 0.5	30	< 20	1.5
9/24/2008	441	10	130	30	4.3
Count	5	10	10	9	10
Average ¹	280	14	198	30	6.1
Min	72	1	20	< 20	1.0
Max	479	59	770	60	25.7

Table 3. Station 230 - Main Stem Chuitna below confluence with Lone Creek

Date	Flow cfs	TSS mg/L	Al - Total µg/L	Al - Dissolved µg/L	Ratio Al _T /Al _D
7/3/2006	NA	< 5	30	< 20	1.5
8/23/2006	NA	26	540	90	6.0
2/24/2007	NA	11	< 20	< 20	1.0
5/25/2007	NA	78	1,380	30	46.0
7/25/2007	NA	9	120	< 20	6.0
10/5/2007	291	< 5	100	30	3.3
2/9/2008	107	< 5	30	< 20	1.5
5/11/2008	924	53	530	50	10.6
8/3/2008	250	< 5	40	< 20	2.0
9/24/2008	585	15	170	40	4.3
Count	5	10	10	9	10
Average ¹	431	21	296	36	8.2
Min	107	5	20	< 20	1.0
Max	924	78	1,380	90	46.0

Figure 1 Station 45 on Main Stem of Chuitna above confluence with Bass Creek

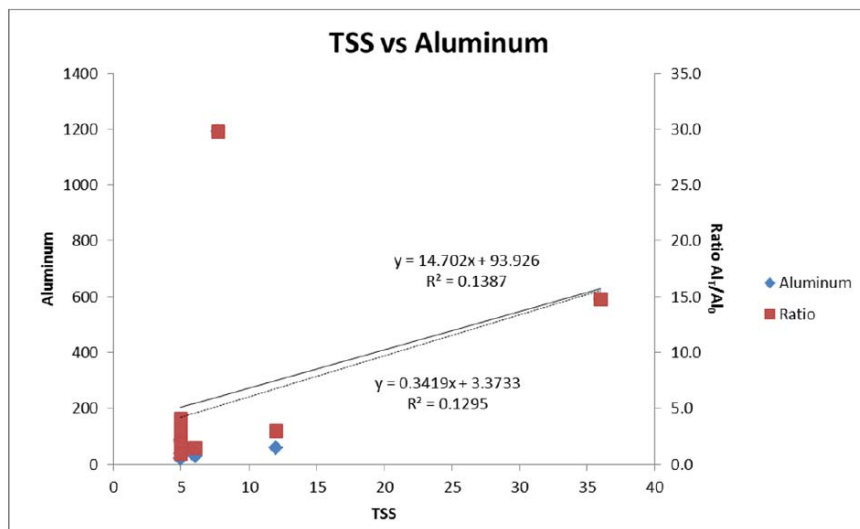


Figure 2 Station 120 on Main Stem of Chuitna between confluence of Bass Creek and Middle Creek

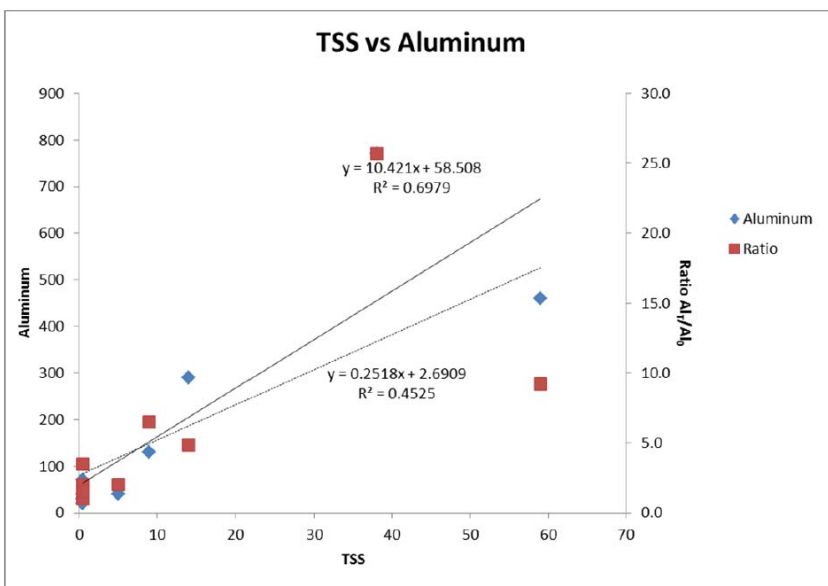


Figure 3 Station 230 on Main Stem of Chuitna below confluence with Lone Creek

